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## (54) Solid lubricant composition

(57) A solid lubricating composition useful for lubricating the flanges of railcar wheels and rails and for other similar applications. The lubricant composition comprises from about 16% to about 25% by weight of a polymeric carrier, from about 49% to about 63% of a lubricating oil, from about 10% to about 16% of a solid lubricating powder, and from about 6% to about 16% of a surface active agent comprising a metallic dithiophosphate and an organic molybdenum compound, all percentages by weight of the total composition. The solid lubricant composition is mixed and introduced into a screw type extruder wherein it is heated and extruded through a die into a waterbath, forming an elastic rod or strand. The lubricant composition is applied to a surface to be lubricated by rubbing it onto the surface in a thin film. The surface active agent enhances the attachment and embedment of the dry lubricating powder into the surface being lubricated, the lubricant composition serving to reduce both wear and friction between contacting surfaces lubricated thereby.

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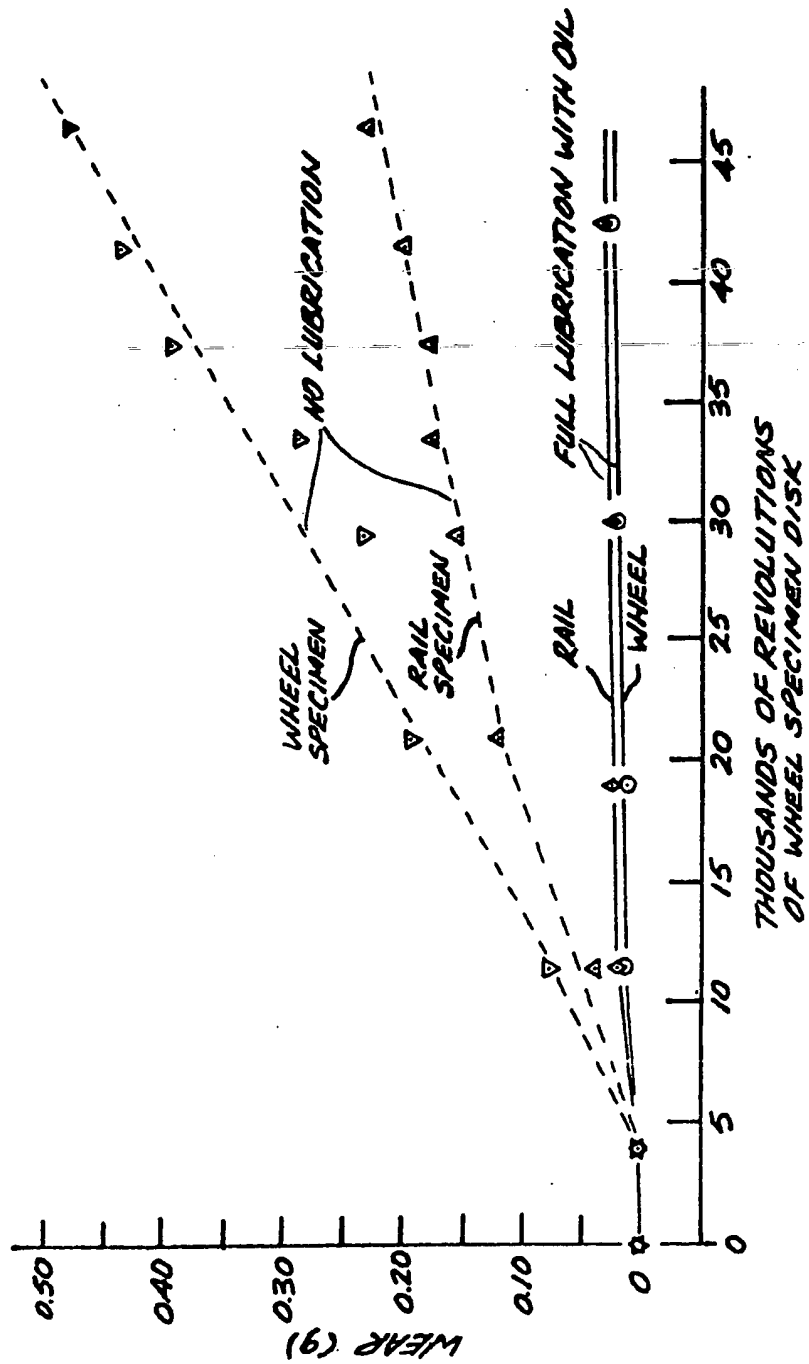
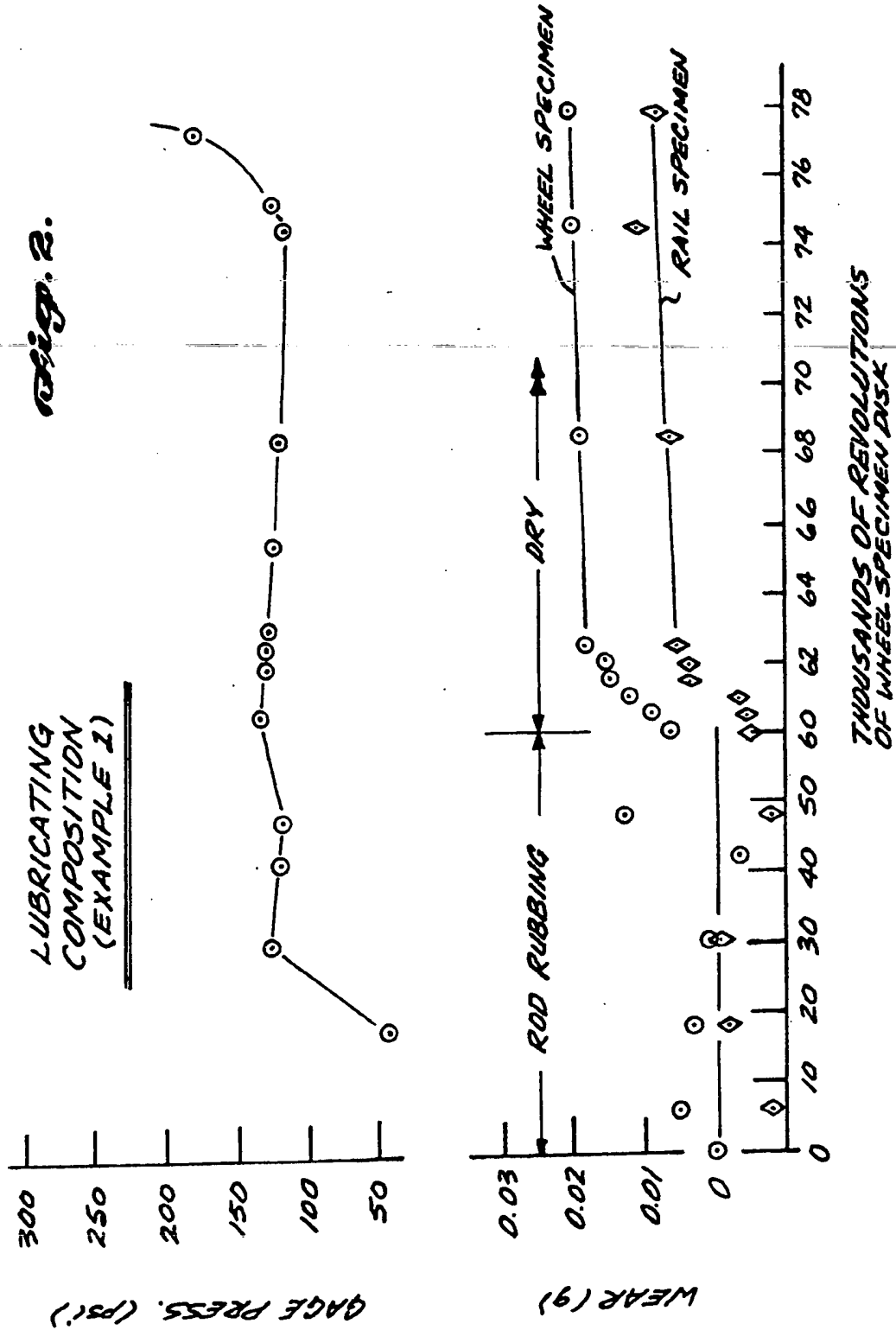
*Fig. 1.*

Fig. 2.



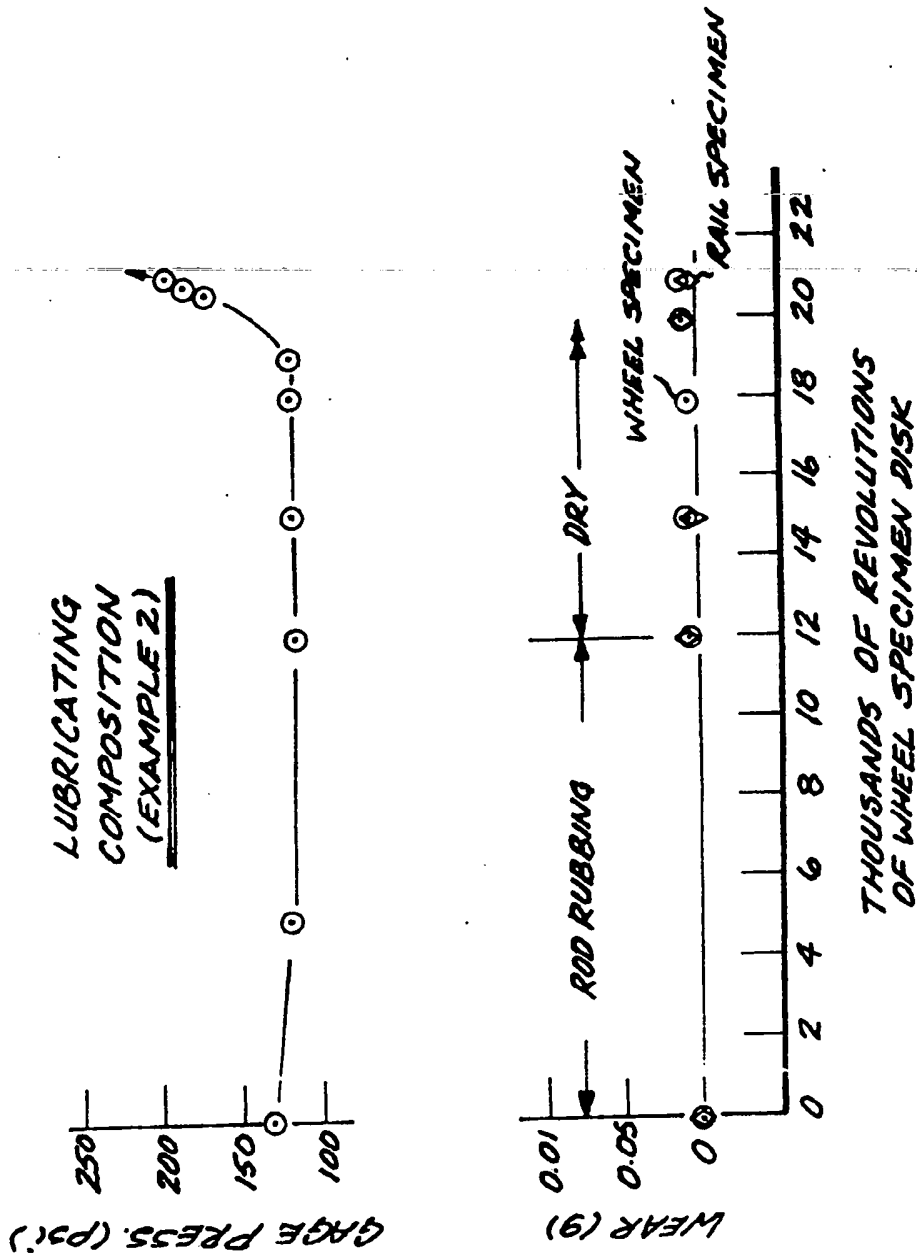


Fig. 3.

## **SOLID LUBRICANT COMPOSITION**

### **Technical Field**

This invention generally relates to an antiwear and friction reducing compound and, more specifically, to a solid lubricant that includes a lubricating powder.

### **Background Information**

Hydrocarbon petroleum based lubricants are normally applied as a liquid or a viscous grease. However, in applications where the surface to be lubricated is part of a body rotating at a relatively high speed, conventional lubricants may be slung off into the environment or may creep onto an adjacent area where lubrication is neither needed nor desired. A problem such as this exists in the rail industry wherein there is a need for lubricating the flange on the periphery of railcar wheels to reduce friction and wear between the wheels and the sides of the steel rail on which the wheels run. Oil or grease applied to the wheel flanges is thrown off, polluting the area adjacent the track. In addition, a conventional lubricant quickly spreads from the flange onto the wheel tread and onto the crown of the rail, thereby reducing traction between the driving wheels of locomotives and the rail, and creating a potential safety hazard by increasing the distance needed to stop the train.

In attempting to avoid the above problems, solid lubricant sticks have been developed in the prior art, which may be used to apply a lubricating film to the flanges of railcar wheels. One of the commercially available lubricating sticks includes a catalytically cured molybdenum disulfide compound molded in a cylindrical foil wrapper. The lubricating stick is mounted in a tubular applicator and is biased against the flange of a railcar wheel by a weight.

A similar stick or rod-type lubricant comprises a graphite based lubricating composition core enclosed in a molded "electric furnace" graphite shell. The graphite stick is placed in a tubular applicator and is biased against the wheel flange with a helical coil spring.

The dry lubricant sticks of the prior art overcome some of the problems associated with lubricating railcar wheels using conventional oil or grease; however, they fail to provide a complete solution to the problem. Both types of prior art dry lubricant sticks are fragile, being made of hard, brittle materials, which tend to break easily. Each of the prior art dry lubricant sticks represents a maintenance problem because of their relatively small physical size and the rate at which they are applied. Due to their relatively short length, they must be replaced approximately every 4,000-6,000 miles -- much too often to be practical for use on trains traveling several hundred thousand miles per year. In addition, it is impractical to mount a lubricant applicator on each wheel of the train, or even on each car. Ideally, one applicator should be mounted on each side of a train, e.g., on two opposite wheels of a locomotive. The applicator should apply a lubricant film to the wheel flange that is transferred to the side of the rail, and from the rail, to all the wheels of trailing cars, on that side of the train. The prior art solid lubricant sticks are unable to provide lubrication to more than a few wheels, because the dry lubricant provided in the sticks does not transfer well and does not attach or bond well to the metallic surface of railcar wheels that subsequently pass over the track.

Other solid lubricating compositions are known in the prior art that might be useful in this type of application. For example, in U.S. Patent No. 3,729,415, a lubricating composition is disclosed comprising a hydrocarbon oil and polyethylene having an average molecular weight within the range of about 1.5 million to 5 million in proportions yielding a jelly-like gel. Related U.S. Patents are Nos. 3,541,011 and 3,547,819, all of which teach that a compound of polyethylene and oil will have the physical characteristics of a liquid, a thin gel, or a rigid gel, depending upon the molecular weight and/or the amount used of the high molecular weight polyethylene.

A solid gel-type lubricant has a number of advantages over the lubricant sticks comprising graphite and molybdenum disulfide. The gel-type lubricant is not brittle and can easily be extruded or molded in almost any form. However, since oil is the lubricating medium in the solid gel, it is not retained on the track very well over an extended period of time and does not provide the long-term wear resistance or the ability to withstand extreme pressures characteristic of dry lubricants, such as graphite.

As an alternative to graphite, metallic powders are known to provide a substantial lubricating benefit when used as an additive in a petrol um

based compound. For example, U.S. Patent No. 2,543,741 teaches that a compound comprising flake copper, lead, and graphite in a petroleum based vehicle is useful for a thread sealing and lubricating composition. Also, in U.S. Patent No. 4,204,968, a lubricant additive composition is disclosed comprising a lubricating liquid carrier containing a mixture of powdered copper and lead metal particles less than 20 microns in diameter which, it is suggested, function "as tiny ball bearings and platelets," operative to plate onto high wear areas.

Other additive materials are also known to enhance the load bearing capabilities of various lubricating base stocks. Zinc di(neo-alkyl) phosphorodithioate is such an additive and its use with cyclohexyl compounds is disclosed in U.S. Patent No. 3,803,037. A lubricating additive is commercially available that includes synthetic sperm oil, zinc dithiophosphate, an organic molybdenum compound, lead naphthenate, and mineral oil, and it is intended to improve the wear resistance of liquid petroleum based oil to which it is added. However, the prior art has not taught the use of such additives in solid lubricants nor with dry powders, nor is it clear that a benefit would accrue from their use therewith, particularly, since the mechanism by which the additives function to improve wear resistance and to reduce friction is not clearly understood.

It will be apparent that the prior art does not include a lubricant composition that is entirely suitable and which meets all of the requirements for lubricating surfaces such as railcar wheel flanges. Accordingly, the present invention is directed to providing such a lubricant composition. Other objects and advantages of the present invention will be apparent from the description that follows hereinbelow.

#### Summary of the Invention

In overcoming the problems related to conventional liquid and grease-type lubricants, the present invention is directed to a solid lubricant composition comprising in percent by weight from about 16% to about 70% of a polymeric carrier in which is dissolved from about 20% to about 70% of a lubricating oil. The composition further includes from about 10% to about 65% of a solid lubricating powder and from about 0.25% to about 18% of a surface active agent that is operative to improve the adhesion and embedment of the solid powder in a surface to which the compound is applied. The surface active agent comprises a metallic dithiophosphate and an organic molybdenum compound.

To apply the lubricant composition to a surface, it is rubbed over the surface, depositing a thin film. The lubricant composition may be formed in a

mold or extruded, and in a preferred form is extruded in a rope-like strand that may be coiled and fed from a container for use in lubricating the wheel flanges of railcars. The rope-like strand of lubricant composition is biased against the flange of a rotating wheel and is transferred in a thin film to the wheel, and thence to a rail on which the wheel runs. As trailing railcars pass over the rail, the composition is transferred from the rail to their wheels. The pressure of the wheels against the rail tends to attach and embed the solid lubricant powder into the metallic surfaces to which it is applied, an action enhanced by the surface active agent.

In one preferred form, the solid lubricant composition comprises from about 16% to about 25% of polyethylene, from about 49% to about 63% of mineral oil, from about 10% to about 16% of the solid lubricating powder, including one or more selected from the group consisting of copper, lead, aluminum, molybdenum disulfide and graphite, and from about 6% to about 16% of a surface active agent, all by weight of the total composition.

A method of preparing a solid lubricant composition as defined above is also provided, wherein a polymeric carrier, a lubricating oil, a lubricating powder and a surface active agent are mixed, formed into a desired shape, and cured.

The polymeric carrier used in the solid lubricating composition may be one or more selected from the group consisting of polyethylene, polypropylene, ethylene copolymer, a metallic ionomer, and polyurethane. The lubricating oil used in the composition is soluble in the polymeric carrier and may be one or more selected from the group consisting of mineral oil, vegetable oil, and synthetic oil.

According to the present invention, a method is also provided for lubricating a moving metallic surface with the solid lubricant composition described above which includes the step of forming the solid lubricant composition into a desired shape and biasing the formed solid lubricant composition against the moving metallic surface. The solid lubricant composition is thus deposited in a thin film on the moving metallic surface and is caused to attach and embed into the metallic surface by applying pressure.

#### Brief Description of the Drawings

FIGURE 1 is a graph showing the wear of a simulated railcar wheel and rail on which the wheel is run as determined in a laboratory test, both under dry conditions and when lubricated by an oil bath, where wear is measured as grams of weight loss as a function of thousands of revolutions of the wheel;

FIGURE 2 is a graph showing the wear of a simulated railcar wheel and rail and the relative friction between them as determined in a laboratory test, when the wheel is lubricated with a lubricant composition made according to Example I, where wear is measured as grams of weight loss and friction is measured in terms of hydraulic fluid pressure (in psi), both determined as a function of thousands of revolutions of the wheel;

FIGURE 3 is a graph showing the wear of a simulated railcar wheel and rail and the relative friction between them as determined in a laboratory test, when the wheel is lubricated with a lubricant composition made according to Example II, where wear is measured as grams of weight loss and friction is measured in terms of hydraulic fluid pressure (in psi), both determined as a function of thousands of revolutions of the wheel.

#### Description of the Preferred Embodiments

As noted above, the present invention was developed particularly for use in lubricating the wheels of a railcar and the track on which those wheels run, both to reduce friction and to reduce wear of the wheels and the rail. However, it is not intended that the solid lubricant composition comprising the present invention be limited to that specific application, since it is also useful in many similar lubricating applications. In general, it has been found that relatively small amounts of the solid lubricating composition may be applied to any metallic surface, thereby greatly reducing friction and improving wear resistance when the surface is subjected to shear forces.

#### EXAMPLE I

A first preferred embodiment of the solid lubricating composition includes the following materials given in terms of their proportion by weight of the total composition:

- fine copper powder 5%<sup>1</sup>;
- fine lead powder 5%<sup>1</sup>;
- mineral oil (motor oil - grade SAE 30) 49%;
- ultrahigh molecular weight polyethylene powder 25%<sup>2</sup>;
- liquid surface active agent (additive ULC) 16%<sup>3</sup>.

<sup>1</sup>Both the copper and lead powders were sized at -325 mesh and were obtained from SCM Metal Products as product codes 411002 and 511013, respectively.

<sup>2</sup>Obtained from American Hoechst Corporation as GUR UHMW-polymer.

3 The liquid surface active agent (additive ULC) was at one time commercially available from United Lubricant Corp., but that company is no longer in business. The surface active agent comprises the following proportions by percent weight: synthetic sperm oil 8%; primary zinc dithiophosphate 3%; organic molybdenum compound 2.4%; lead naphthenate 4%; and mineral oil 82.6%.

5 The above materials were introduced into a bowl in the indicated proportions and mixed thoroughly by hand with a spoon. (Larger quantities of the materials comprising the lubricant composition made according to other Examples described hereinbelow were mixed in a commercial dough mixer.) Mixing continued for sufficient time to produce a homogeneous, viscous mass, referred to as "a slurry." The slurry was then introduced into the feed throat of a conventional single screw extruder of the type used for extruding plastics material. The oil included in the slurry helped to provide lubrication for the extruder screw and improved the output rate of the extruder.

15 The extruder used in this process has a one-inch diameter, 24:1 screw, and includes three zones of electrical resistance heating disposed along the length of its output barrel. Contrary to normal practice when used with plastic materials, no cooling was used on the feed throat of the extruder in processing the lubricant composition. A temperature of approximately 180°F was measured on the surface of the feed throat; this elevated temperature was probably due to heat conducted from the output barrel. Heat was applied to the barrel of the extruder using the electrical resistance heaters to achieve the following temperatures at the indicated zones: zone 1 - 275°F; zone 2 - 310°F; and, zone 3 - 350°F (where zone 1 is closest to the feed throat). The barrel of the extruder was terminated in a die designed for use under a water bath and sized to produce an extrudate having a circular cross-section of 3/16 inch in diameter. In various other of the following examples described hereinbelow, dies of differing cross-sections including 1/2 inch, 3/4 inch, and 1 inch were also used. The extruder screw was turned at approximately 150 r.p.m. Since the die was submerged in a water bath, the extrudate emerging from the die was cooled so that it possessed sufficient tensile strength to enable it to be pulled from the downstream end of the water bath and cut into appropriate lengths. The extrusion rate provided by the particular screw extruder used was approximately 10 pounds per hour. A twin screw extruder and continuous feed processing would substantially improve the production rate.

35 In making the laboratory tests that provided the data shown in FIGURES 1-3, a machine was used that included two disks driven by a hydraulic motor. One of the disks was made from a section of railcar wheel and the other

from a section of rail. The disks were positioned on parallel axles so that their peripheral edges were biased into contact with a constant load, and were run at two different speeds, providing a 25% slippage rate between the disks, which is typical of the slippage between a wheel flange and a rail.

5           With reference to FIGURE 1, the benefits of providing lubrication to the wheel of a railroad car are graphically shown in terms of the wear of a simulated wheel and rail on which the wheel is run, measured by weight loss (in grams) as a function of thousands of revolutions of the wheel on the rail. The two dashed lines at the top of the graph (FIGURE 1) show the wear sustained by both  
10 the simulated wheel and the rail while operated dry, i.e., without any lubrication. This wear is rather significant compared to the two solid lines at the bottom of the graph, which show virtually no wear resulting from operation over the same number of revolutions when both the simulated rail and the wheel are continually lubricated with an oil bath.

15           FIGURE 2 graphically shows the advantages of using the lubricant composition made according to Example I for reducing the wear sustained by a simulated railcar wheel and a rail in terms of weight loss (in grams) and for reducing the friction between the two surfaces measured in terms of the pressure developed in the hydraulic system used to drive the motor by which the disks  
20 simulating the wheel and rail were rotated, both determined as a function of thousands of revolutions of the wheel specimen. On the left side of the graph, the test was conducted by positioning a rod comprising the lubricant composition of Example I, so that it lightly rubbed against the rotating wheel specimen. This was done for the first 60,000 revolutions of the disk, and generally prevented wear of  
25 both specimen disks even after the lubricant composition was no longer applied so that the only lubrication was that due to the film remaining from the initial application. The variations in weight loss for the data points shown on the graph, about the virtually flat line indicative of wear are due to the gain or loss of the lubricant composition from the wheel and rail specimen disks rather than actual  
30 changes in the mass of metal comprising the disks. The friction of the wheel specimen against the rail specimen disk was maintained at a relatively low level, even after the lubricant composition rod was no longer applied to the wheel specimen, until at approximately 76,000 revolutions, the friction started to increase dramatically, accompanied by a dramatic increase in noise level produced by the  
35 disks, indicating that the residual lubrication provided by the lubricant composition had failed. Based on this test, it appears that the lubricant composition will

provide a substantial reduction in friction and wear when applied to lubricate the wheel of a railcar.

#### EXAMPLE II

A compound similar to that of Example I was made, except that the copper and lead powders were replaced with a powdered aluminum bronze metal alloy designated D65-MET, which is commercially available from Metco Corporation as product code 51F-NS, for use as a flame sprayed antiwear coating.

The following materials and proportions by weight were used for the lubricant composition:

aluminum bronze powder (D65-MET) 10%<sup>1</sup>;  
oil 49%;  
ultrahigh molecular weight polyethylene 25%<sup>2</sup>;  
liquid surface active agent (additive ULC)<sup>2</sup> 16%.

<sup>1</sup>The D65-MET alloy comprises the following ingredients by percentage weight: iron 0.81%; aluminum 10.19%; copper 88.7%.

<sup>2</sup>Same as in Example I.

The compound of Example II was made according to the method used to make the compound of Example I and was extruded into a rod having similar lubricating capability. The results of a test made in the same manner as the tests performed on Example I, described above, were also made to determine the wear reduction and friction reducing characteristics of the lubricant composition made according to Example II. The results are shown in FIGURE 3, wherein a rod of the lubricant composition was rubbed against a simulated railcar wheel disk during the first 12,000 revolutions of the disk, and thereafter was withdrawn so that the disk ran with only the residual lubricating film provided by the initial application. Again, minimal wear of the specimen disks was noticed during both the initial portion of the test when the rod was applied and after the rod was withdrawn; however, the residual protection provided after the lubricating composition was no longer applied lasted for only approximately 9,000 revolutions, as is evident by reference to the upper portion of FIGURE 3, wherein gauge pressure is shown to rise dramatically between 20,000-22,000 revolutions of the wheel, indicating a substantial increase in friction between the wheel and the rail.

### EXAMPLE III

A lubricant composition was prepared by mixing the following ingredients in the indicated proportions by weight:

- 5 copper powder 7.6%;
- lead powder 7.6%;
- a metal alloy powder 5.2%<sup>1</sup>;
- oil 52.4%;
- ultrahigh molecular weight polyethylene 17.5%;
- ethylene vinyl acetate copolymer 3.8%<sup>2</sup>;
- 10 surface active agent 5.9%<sup>3</sup>.

<sup>1</sup>Comprising copper 70%, and zinc 30% (obtained from Atlantic Metal Powders, Inc. as Richgold No. 129).

<sup>2</sup>Obtained from Allied Chemicals as Stock No. AC400A.

- 15 <sup>3</sup>Comprises inactive sulphurized fat 20%; primary zinc dithiophosphate 20%; organic molybdenum compound 20% (sulphurized oxymolybdenum organophosphorodithioate, sold as MOLYVAN<sup>®</sup>L; this and other organic molybdenum compounds are available from R. T. Vanderbilt Company, Inc.); and lead naphthenate 40%.

The above-listed materials were mixed as a slurry and introduced into the feed throat of the extruder for extrusion according to the process described above for Example I, producing a one-inch diameter extrudate rod, which was subsequently cut into one-foot lengths. The one-foot lengths of the lubricant composition made according to Example III were installed in eight cylindrical holders on the axles of three locomotives of a train comprising 65 coal cars. The holders were positioned so that the ends of the rods were biased into contact with the wheel flanges using a mass of approximately one pound to provide the biasing force. With the lubricant composition thus being applied, the train was operated three times per day over a railroad approximately 80 miles in length, hauling coal in one direction while returning with empty cars in the opposite direction. The lengths of the lubricant composition rods were monitored as a function of time, and it was noted that the lubricant composition was being deposited onto the wheels of the cars trailing the locomotive. This was determined by inspecting the wheels of the trailing cars and by chemically analyzing a sample rubbed from the wheels of the 40th car behind the locomotives. It is thus apparent that the lubricant composition transferred from the flanges of the locomotive wheels to the rail, and subsequently was transferred from the rail to the wheels of the trailing cars.

#### EXAMPLE IV

A solid lubricant composition was made comprising the following materials by percentage weight:

- ultrahigh molecular weight polyethylene 14.6%;
- 5 low molecular weight polyethylene 3.2%;
- fine copper powder 6.3%;
- fine lead powder 6.3%;
- oil (motor oil of grade SAE 30) 67%;
- surface active agent 1.5%<sup>1</sup>;
- 10 lead naphthenate concentrate 1.1%.

<sup>1</sup>Comprising the same composition as the surface active agent used in Example III.

The above ingredients were mixed to form a low viscosity slurry, which was poured into closed cube shaped molds measuring three inches on a side. The molds were heated in an oven at 350° for three hours and allowed to cool to room temperature. The solid lubricant composition produced according to this process was a relatively hard composition which could be cut into blocks suitable for lubricating the wheel flanges of railcars.

To evaluate the performance of the solid lubricant made according to Example IV, the blocks were installed in fixtures on a special rail maintenance car used to grind the tops of rails on a high speed transit system. This transit system uses linear induction motors to propel the cars and, therefore, unlike a conventional train, there is no requirement for driving the cars by means of friction between the wheels of a locomotive and the rails. However, there was concern about the effects of reduced braking efficiency if the solid lubricant should migrate to the top or crown of the rail, or spread onto the wheel tread. To test the degradation of braking distance caused by the solid lubricant composition prepared according to Example IV, it was applied directly to the top of the rails using the special rail maintenance car as an application vehicle. Tests then conducted in which the railcars were driven over the sections of track thus treated and emergency brakes were applied. The braking distance of the train on the portion of the track which was lubricated was well within acceptable limits. Furthermore, the lubricant composition made according to Example IV was found to reduce wear and unwanted friction between the rails and the wheels.

#### EXAMPLE V

As an alternative to the solid lubricant composition that is formed in a rod or mold, a lubricant composition was prepared suitable for spraying onto a surface subject to wear and friction, using the following materials in the indicated proportions by weight:

urethane 68.8%<sup>1</sup>;  
liquid surface active agent 25% (additive ULC)<sup>2</sup>;  
fine copper powder 3.1%; and  
fine lead powder 3.1%.

<sup>1</sup>Liquid, water curing polyurethane, obtained from Spencer Kellogg Corp. as Spenkel M21-40X.

<sup>2</sup>Comprising the same materials as used in the surface active agent of Example I.

The above materials were thoroughly mixed by hand and the resulting slurry was thinned with xylene to a relatively thin consistency suitable for spraying. The compound thus prepared was sprayed onto a simulated railcar wheel of the type used in testing the lubricant composition of Examples I and II, to a coating thickness of approximately 0.0006 inches. For purposes of comparison, a separate wheel specimen was coated with a mixture comprising only the urethane and the surface active agent omitting the copper and lead powders, and another wheel specimen was coated with only the urethane and the copper and lead powders, omitting the surface active agent. Table 1 shows the relative wear of the specimens, and the friction coefficient for three different operating conditions designated "mild," "severe," and "very severe," relating to the loading applied to the disks and the skew angle at which they were run, as follows: mild -- 12 lb. load, 0.5° skew; severe -- 12 lb. load, 1.1° skew; very severe -- 19 lb. load, 5° skew.

**TABLE 1**  
**Wear of Test Specimens**

	<u>Materials</u>	<u>Conditions</u>	<u>Rail Wear</u>	<u>Friction Coeff.</u>
	No coating	Mild	1	0.40
5	Urethane + Surface Active Agent	Mild	0.21	0.35
	Urethane + metal powders	Mild	0.21	0.22
	Lubricant composition Example V	Mild	0	0.20
10	No coating	Severe	1	0.45
	Urethane + Surface Active Agent	Severe	0.51	0.25
	Urethane + metal powders	Severe	0.36	0.35
15	Lubricant composition (Example V)	Severe	0.007	0.20
	No coating	Very Severe	14.2	Not determined
20	Lubricant composition (Example V)	Very Severe	2.3	Not determined

Based on the results of these tests, it is apparent that the urethane and surface active agent or the urethane and metal powders are each capable of providing reduced wear and friction; however, the combination of materials comprising the lubricant composition of Example V is far more effective in reducing both wear and friction. This synergistic result is believed to occur because of the action of the surface active agent in enhancing the embedment of the metallic powders in the surfaces being lubricated. The mechanism by which this action occurs is not understood, although its effect is readily apparent. It is believed that the same synergistic benefit of using a surface active agent in combination with a solid lubricating powder occurs in the other examples described herein.

#### EXAMPLE VI

A lubricant composition was prepared from the following ingredients in the indicated proportions by weight:

- aluminum bronze powder (D65-MET) 8%;
- 5 metal alloy powder (Richgold No. 129) 4%;
- fine copper powder 3%;
- oil (ISO VG 680) 63%;
- ultrahigh molecular weight polyethylene 8%;
- ethylene vinyl acetate copolymer 8%;
- 10 surface active agent 6%<sup>1</sup>.

<sup>1</sup>Same composition as the surface active agent used in Example III.

The above materials were mixed and processed according to the method of Example I and were extruded into a one-inch diameter rod which was cut into one-foot lengths. The rods were then used to lubricate the wheel flanges of locomotives as described for Example III, with similar results.

#### EXAMPLE VII

A lubricant composition was prepared from the following ingredients in the indicated proportions by weight:

- 20 molybdenum disulfide 6.3%<sup>1</sup>;
- ultrahigh molecular weight polyethylene 11.8%;
- ethylene vinyl acetate copolymer 7.1%;
- fine copper powder 3.2%;
- oil (ISO VG 680) 71%;
- 25 tackifier 0.1%<sup>2</sup>;
- surface active agent 0.5%<sup>3</sup>.

<sup>1</sup>Technical grade powder obtained from Climax Molybdenum Co.

<sup>2</sup>Latex compound obtained from Heveatex Corporation as Heveanol H-1501.

30 <sup>3</sup>Same composition as the surface active agent used in Example III.

The above materials were processed in accordance with the method of Example I, and were extruded as a one-inch diameter rod having the same elastic properties as the compositions of Examples I and III. The lubricant composition of Example VII was also found to deposit a lubricating film when rubbed onto a metallic surface.

#### EXAMPLE VIII

A lubricant composition was made with the following ingredients in the indicated proportions by weight:

- 5 molybdenum disulfide 1.2%;
- fine copper powder 3.1%;
- graphite 5%<sup>1</sup>;
- oil (ISO VG 680) 70%;
- ultrahigh molecular weight polyethylene 11.8%;
- ethylene vinyl acetate copolymer 7.0%;
- 10 tackifier 0.3%;
- surface active agent 1.6%<sup>2</sup>.

<sup>1</sup>Obtained from Superior Graphite Co. as #1 Large Flakes.

<sup>2</sup>Same composition as the surface active agent used in Example III.

- 15 The materials listed above were processed in accordance with the method of Example I and were used to lubricate the wheel flanges of locomotives as described in Example III, exhibiting similar friction and wear reduction properties.

#### EXAMPLE IX

- 20 A solid lubricant composition was made using the materials in the indicated proportions by weight:

- fine copper powder 6.5%;
- fine lead powder 6.5%;
- oil (ISO VG 680) 67.1%;
- 25 liquid surface active agent (additive ULC) 1.5%<sup>1</sup>;
- ultrahigh molecular weight polyethylene 15.1%;
- ethylene vinyl acetate copolymer 3.3%.

<sup>1</sup>Comprising the same materials used for the surface active agent in Example I.

- 30 The preceding materials were processed in accordance with the method used in Example I and were extruded into a one-inch diameter rod that was cut into one-foot lengths. One of the rods was placed in a holder attached to provide lubrication to the flange of a wheel on a locomotive (by rubbing against the wheel). The locomotive was part of a train having four locomotives, pulling a special lubricator car and 85 additional cars each loaded with 100 tons of ballast.
- 35 The train was run around a test track loop of approximately 2.8 miles in length,

while the lubricant compound of Example IX was biased into contact with the wheel flange of the locomotive with a force of approximately 12 pounds. After six laps around the test loop, the rod of lubricant composition had deposited a visible film on the surfaces of the wheels of each of the succeeding cars and along the entire length of the track. The film deposited by the lubricant rod was clearly visible, and chemical analysis proved that the visible film comprised the lubricant composition of Example IX. It was also noted during the test that wheel flange noise was markedly reduced and that the normal surface roughness of the part of the rail contacted by the wheel flange was reduced.

10

#### EXAMPLE X

A lubricant composition was made with the following ingredients in the indicated proportions by weight:

- fine copper powder 7.8%;
- fine lead powder 7.8%;
- 15 oil (ISO VG 680) 16.6%;
- jojoba oil 25.0%;
- ultrahigh molecular weight polyethylene 19.0%;
- low molecular weight polyethylene 7.1%;
- liquid surface active agent (additive ULC) 16.7%<sup>1</sup>.

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<sup>1</sup>Comprising the same materials as in the surface active agent used in Example I.

The materials listed above were mixed into a viscous slurry and placed into copper tubes one inch in diameter and approximately one foot in length. The tubes were capped and heated in a furnace at a temperature of 375°F for two hours. Before cooling completely, the tubes were removed from the furnace, uncapped, and the lubricant composition was forced out. The rods thus formed were found to comprise a hard, elastic solid material having the same lubricating properties as the extruded rods of Examples I and III. Tests of the lubricant composition formed according to the process of Example X showed that it had the same ability to lubricate wheel flanges on a high-speed light rail transit train as the rods which were extruded.

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#### EXAMPLE XI

The same materials in the same percentages by weight as in Example X were used to produce a lubricant composition, except that the ultrahigh molecular weight polyethylene and low molecular weight polyethylene were replaced by a high molecular weight polyethylene. Similar results were obtained

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in evaluating the lubricant composition thereby produced.

EXAMPLE XII

A lubricant composition similar to that produced in Example X was made by replacing the ultrahigh molecular weight polyethylene and low molecular weight polyethylene with an equivalent proportion by weight of polypropylene. The resulting lubricant composition appeared to have similar properties in reducing friction and wear as that produced in accordance with Example X.

EXAMPLE XIII

A lubricant composition was made in accordance with the method of Example X using the same ingredients and the same proportions, except that the ultrahigh molecular weight polyethylene and low molecular weight polyethylene were replaced by a metallic ionomer, specifically a zinc ion based ionomer obtained from DuPont under the product name SURLYN 9970. The lubricant composition thereby produced appeared to have similar qualities to that of the lubricant composition of Example X.

EXAMPLE XIV

A lubricant composition was made according to the method of Example X and the same materials were used in the same proportions, except that the ultrahigh molecular weight polyethylene and low molecular weight polyethylene were replaced by a low molecular weight ionomer, specifically one obtained from Allied Chemicals under the product name ACLYN 201A. The wear extending and friction reducing properties of the resulting lubricant composition were similar to those of the lubricant composition of Example X.

EXAMPLE XV

It is also contemplated that a composition can be made comprising the following ingredients by weight:

ultrahigh molecular weight polyethylene 8%;  
ethylene-acrylic acid copolymer 2%<sup>1</sup>;  
fine copper powder 32.5%;  
fine lead powder 32.5%;  
surface active agent 5%<sup>2</sup>;  
oil 20%.

<sup>1</sup>Obtained from Allied Chemicals as product ACE540A.

<sup>2</sup>Comprising the same materials used in the surface active agent of Example III.

It is believed that a lubricant composition made using the above listed materials according to the method of Example I will have superior lubricating properties and will be useful for lubricating the wheel flanges of a railcar and in other similar lubricating applications due to the relatively higher concentration of solid powders, which should provide enhanced antiwear capability.

#### EXAMPLE XVI

It is also contemplated that a lubricant composition can be made from the following materials in the indicated proportions by weight:

- 10       ultrahigh molecular weight polyethylene 8%;
- ethylene-acrylic acid copolymer 2%;
- molybdenum disulfide 32.5%;
- graphite 32.5%;
- surface active agent 5%<sup>1</sup>;
- 15       oil 20%.

<sup>1</sup>Comprising the same ingredients used in the surface active agent of Example III.

A lubricant composition comprising the preceding materials is believed to have superior lubrication properties for applications wherein the antiwear capability of the solid lubricating powders, i.e., graphite and molybdenum disulfide are likely to provide an advantage. The relatively higher percentage of these dry lubricating powders in the lubricant composition made according to Example XVI (following the method of Example I) should provide potentially greater antiwear characteristics than other lubricant compositions having a substantially lower percentage of dry lubricating powders.

25       In each of the preceding examples wherein polyethylene is used as a polymeric carrier, it is preferable to use a mixture of ultrahigh molecular weight polyethylene (having a molecular weight in excess of 750,000) in combination with a lower molecular weight polyethylene (having a molecular weight less than 10,000) to insure the solubility of the oil and to avoid having the oil bleed from the solid lubricant composition after it has been formed into a rod. Alternatively, a high or medium molecular weight polyethylene may be used (having a molecular weight between 100,000 and 600,000) with substantially the same result. In any case, it is desirable that the oil used be soluble within the polyethylene and that the resulting lubricant composition be relatively dry, having little or no oil bleeding from the surface.

The relatively high percentage of oil present in the solid lubricant compositions made as described above enhances the extrusion process and in addition serves an important function in reducing the friction between surfaces to which it is applied. These surfaces are subject to wear during the time needed for the dry lubricating powders comprising the present solid lubricant composition to attach and become embedded in the surfaces. If insufficient lubricating oil is provided in the lubricant composition, the dry lubricant powders are carried away from the surfaces to which they should attach, by the shearing action of one surface rubbing against the other. However, once the dry lubricant powders have become embedded and attached to the surfaces, the lubricating oil ceases to have an important function in extending the antiwear and friction reducing properties of the lubricant composition. As noted previously, the surface active agents tend to enhance the attachment and embedment of the dry lubricant powders, both the metallic powders, and the nonmetallic powders, (graphite and/or molybdenum disulfide) to the surface being lubricated in a manner not previously known to occur. The pressure between the surface to which the lubricant composition is applied and another surface coming into contact therewith tends to force the lubricating powder into the metallic interstices of the surfaces, reducing the roughness of both surfaces and protecting them against wear.

In addition to the metallic powders used in the preceding examples, it is also contemplated that alloys of cadmium and zinc, cadmium and tin, bismuth and zinc, bismuth and tin, and other similar soft metallic elements and alloys of such elements might be useful in the lubricant composition of the present invention. The metallic powders should range in size from -325 mesh to -200 mesh to insure the attachment of the powder to the metallic surfaces being lubricated. Where a nonmetallic material such as graphite is used, the particulate size should range from about 200 nanometers to about 0.5 millimeters.

CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A solid lubricant composition comprising:
  - (a) from about 16% to about 70% by weight of a polymeric carrier;
  - (b) from about 20% to about 70% by weight of a lubricating oil, said lubricating oil being soluble in said polymeric carrier;
  - (c) from about 10% to about 65% by weight of a solid lubricating powder; and
  - (d) from about 0.25% to about 18% by weight of a surface active agent comprising a metallic dithiophosphate and an organic molybdenum compound.
2. The solid lubricant composition of Claim 1, wherein the polymeric carrier is selected from one or more of the group consisting of polyethylene, polypropylene, ethylene copolymer, a metallic ionomer and polyurethane.
3. The solid lubricant composition of Claim 1, wherein the surface active agent further includes one or more selected from the group consisting of synthetic sperm oil, mineral oil, inactive sulfurized fat, and a metallic naphthenate.
4. The solid lubricant composition of Claim 3, wherein the metallic naphthenate comprises lead naphthenate.
5. The solid lubricant composition of Claim 1, wherein the solid lubricating powder is selected from one or more of the group consisting of copper powder, lead powder, molybdenum disulfide, graphite, an alloy of iron, aluminum, and copper in a powder form, an alloy of copper and zinc in powder form, an alloy of cadmium and zinc in powder form, an alloy of cadmium and tin in powder form, an alloy of bismuth and zinc in powder form, and an alloy of bismuth and tin in powder form.

6. The solid lubricant composition of Claim 1, wherein the solid lubricating powder comprises a metallic powder.

7. The solid lubricant composition of Claim 6, wherein the metallic powder comprises a mixture of copper and lead powders.

8. The solid lubricant composition of Claim 6, wherein the metallic powder ranges in size from about -325 mesh to about -200 mesh.

9. The solid lubricant composition of Claim 1, consisting of:

- (a) about 18% by weight of the polymeric carrier;
- (b) about 50% by weight of the lubricating oil;
- (c) about 27% by weight of the solid lubricating powder;

5 and ,

- (d) about 5% by weight of the surface active agent.

10. The solid lubricant composition of Claim 2, wherein the polyethylene comprises a mixture of an ultrahigh molecular weight polyethylene and a low molecular weight polyethylene.

11. The solid lubricant composition of Claim 5, wherein the graphite has a particulate size ranging from 200 nm to 0.5 mm.

12. The solid lubricant composition of Claim 3, wherein the surface active agent comprises about 8 parts by weight of synthetic sperm oil, about 3 parts by weight of zinc dithiophosphate, about 2.4 parts by weight of organic molybdenum compound, about 4 parts by weight lead naphthenate and 82.6 parts by weight mineral oil.

13. The solid lubricant composition of Claim 3, wherein the surface active agent comprises about equal parts by weight of inactive sulfurized fat, zinc dithiophosphate, an organic molybdenum compound, and about two parts by weight of lead naphthenate.

14. The solid lubricant composition of Claim 3, wherein the surface active agent comprises about 3 parts by weight inactive sulfurized fat,

about 1 part by weight zinc dithiophosphate and about 2 parts by weight organic molybdenum compound.

15. The solid lubricant composition of Claim 1, wherein the ratio of the solid lubricating powder to the surface active agent by weight is in the range of 5/1 to 20/1.

16. The solid lubricant composition of Claim 1, wherein the lubricating oil is selected from the group consisting of vegetable oil, mineral oil, and synthetic oil.

17. The solid lubricant composition of Claim 1, wherein the composition is mixed and extruded in a flexible strand which may be freely coiled.

18. The solid lubricant composition of Claim 1, wherein the composition is mixed and molded into one of a brick and a rod.

19. The solid lubricant composition of Claim 1, wherein the composition is cured by heating to a temperature in excess of 300°F.

20. The solid lubricant composition of Claim 1, wherein the polymeric carrier comprises from about 16% to about 25% by weight of polyethylene, the lubricating oil comprises from about 49% to about 63% of mineral oil, the solid lubricating powder comprises from about 10% to about 16% by weight and includes one or more selected from the group consisting of copper, lead, aluminum, molybdenum disulfide and graphite, and the surface active agent comprises from about 6% to about 16% by weight.

21. A method for preparing a solid lubricant composition suitable for reducing friction and wear of a metallic surface when rubbed onto the surface in a thin film, comprising the steps of:

- (a) mixing a polymeric carrier, a lubricating oil, a lubricating powder and a surface active agent;
- (b) forming the mixture into a desired shape; and
- (c) curing the mixture.

22. The method of Claim 21, wherein the step of forming the mixture comprises the step of extruding the mixture into a flexible strand.

23. The method of Claim 21, wherein the step of forming the mixture comprises the step of molding the mixture into one of a brick and a rod.

24. The method of Claim 21, wherein the step of curing the mixture comprises the step of heating the mixture to a temperature in excess of 300°F for a sufficiently long time to achieve homogeneous melting of the polymeric carrier.

25. The method of Claim 21, wherein the polymeric carrier is selected from one or more of the group consisting of polyethylene, polypropylene, ethylene copolymer, a metallic ionomer, and polyurethane.

26. The method of Claim 21, wherein the lubricating oil is soluble in the polymeric carrier and is selected from one or more of the group consisting of mineral oil, vegetable oil, and synthetic oil.

27. The method of Claim 21, wherein the solid lubricating powder is selected from one or more of the group consisting of metallic powders, graphite and molybdenum disulfide.

28. The method of Claim 27, wherein the metallic powders are selected from one or more of the group consisting of copper, lead, an alloy of copper, aluminum and iron, an alloy of copper and zinc, an alloy of cadmium and zinc, an alloy of cadmium and tin, an alloy of bismuth and zinc, and an alloy of  
5 bismuth and tin.

29. The method of Claim 27, wherein the metallic powders are sized in the range -325 to -200 mesh.

30. The method of Claim 27, wherein the metallic powders comprise a mixture of substantially equal parts by weight of copper and lead.

31. The method of Claim 21, wherein the surface active agent comprises a metallic dithiophosphate, an organic molybdenum compound, and one or more selected from the group consisting of synthetic sperm oil, mineral oil, inactive sulfurized fat, and a metallic naphthenate.

32. The method of Claim 31, wherein the metallic naphthenate comprises lead naphthenate.

33. A method for lubricating a moving metallic surface to reduce friction and wear, using a solid lubricant composition comprising a polymeric carrier, a lubricating oil, a solid lubricating powder, and a surface active agent, comprising the steps of:

- 5 (a) forming the solid lubricant composition into a desired shape;
- (b) biasing the formed solid lubricant composition against the moving metallic surface;
- (c) depositing a thin film of the solid lubricant composition on the moving metallic surface; and
- 10 (d) applying pressure to attach and embed the solid lubricant powder into the metallic surface.

34. The method of Claim 33, wherein the step of forming the solid lubricant composition comprises the step of forming it into one of a flexible strand, a brick, and a rod.

35. The method of Claim 33, further comprising the step of enhancing the attachment and embedment of the solid lubricating powder on the metallic surface using the surface active agent.

36. The method of Claim 33, wherein the solid lubricating powder is selected from one or more of the group consisting of a metallic powder, graphite and molybdenum disulfide.

37. The method of Claim 36, wherein the metallic powder comprises a mixture of copper and lead powders having a size in the range -325 to -200 mesh.

38. The method of Claim 33, wherein the polymeric carrier is selected from one or more of the group consisting of polyethylene, polypropylene, ethylene copolymer, a metallic ionomer, and polyurethane.

39. The method of Claim 33, wherein the surface active agent comprises a metallic dithiophosphate and an organic molybdenum compound.

40. The method of Claim 33, wherein the moving metallic surface comprises a wheel of a railcar, further comprising the step of transferring the solid lubricant composition from the wheel to a rail on which the wheel runs and, thence, to a plurality of other railcar wheels.

41. The method of Claim 40, wherein the step of applying pressure comprises the step of rolling the railcar wheels along the rail.